An Unresolved Resonance Evaluation for ^{233}U from 600 eV to 40 keV

L. C. Leal, H. Derrien, N. M. Larson, and A. Courcelle

Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee, 37831, USA
leallc@ornl.gov

INTRODUCTION

A resolved resonance analysis of experimental neutron transmission and cross section of ^{233}U was performed using the Reich-Moore formalism in the computer code SAMMY.[1] The evaluation was carried out in the energy region from thermal to 600 eV, resulting in a set of resonance parameters that well describes the experimental data. Above 600 eV the fluctuations in the measured cross sections are smaller than those in the resolved range but are still important for calculating the energy self-shielding of the cross section. These fluctuations are due to unresolved multiplets of resonances for which it is not possible to determine parameters of the individual resonances as is done in the resolved region. The mechanism utilized for the cross-section treatment in the unresolved region is based on average values of physical quantities obtained in the resolved range. This knowledge of the average values for level spacings, strength functions, widths, and other relevant parameters is used to infer their behavior in the unresolved energy region.

METHOD OF EEVALUATION

Four sets of experimental data were used in the evaluation:

1. Effective average total cross sections of Guber et al.[2] obtained from experimental transmission measurements. These transmission measurements were performed at a 79.8-m flight path with sample thicknesses of 0.0119 at/b and with the sample cooled to 11 K. The average cross sections were derived by Derrien et al.[3] and corrected for self-shielding; the data were used from 600 eV to 40 keV.
2. Fission cross sections of Guber et al.[4] taken on the 80-m flight path. These data were used from 600 eV to 40 keV.
3. Fission and capture data of Weston et al.[5] obtained from the capture-to-fission ratio measurements done at a 25.2-m flight path from 600 eV to 2 keV.
4. Capture data of Hopkins extracted from capture-to-fission ratio measurements done with a collimated neutron beam incident in a target placed in a cadmium-loaded liquid scintillator.[6]

The computer code SAMMY was used to fit the data in the energy region from 600 eV to 40 keV. The average parameters obtained in the resolved resonance region and used in the SAMMY unresolved fit are shown in Table I. The parameters are total angular momentum J, average level spacing $\langle D \rangle$, strength function S_n, fission width $\langle \Gamma_f \rangle$, effective fission degrees of freedom N_{eff}, and capture width $\langle \Gamma_\gamma \rangle$.

TABLE I. Average Values of the Resonance Parameters Input Used in the SAMMY Unresolved Resonance Calculations for orbital angular momentum l=0.

J	$\langle D \rangle$ (eV)	$S_n \times 10^4$	$\langle \Gamma_f \rangle$ (meV)	N_{eff}	$\langle \Gamma_\gamma \rangle$ (meV)
Mixed levels	0.52 ± 0.08	0.895 ± 0.047	496		39.0 ± 3.0
2+	1.19 ± 0.12		760 ± 60	4.0	
3+	0.92 ± 0.10		296 ± 30	2.0	

The resulting unresolved parameters obtained from the SAMMY fit were reported to ENDF at 27 reference energies. The reference energies were determined based on the observed fluctuations in the experimental data, which are due to unresolved multiplets of resonances. These reference energies are 600, 715, 815, 930, 1050, 1200, 1300, 1380, 1440, 1500, 1670, 1800, 1960, 2255, 2790, 3450, 5500, 7000, 7550, 8000, 8700, 10000, 12000, 15000, 20000, 25000, 30000, and 35000 eV.

The results of the fit of the experimental data are given in Fig 1. The experimental cross section data shown in Fig. 1 are the total cross section of Guber et al., the fission cross section of Guber et al., the capture cross section of Weston et al., and the capture cross section of Hopkins et al. The solid line represents the SAMMY fit to the data showing good agreement with the experimental data.

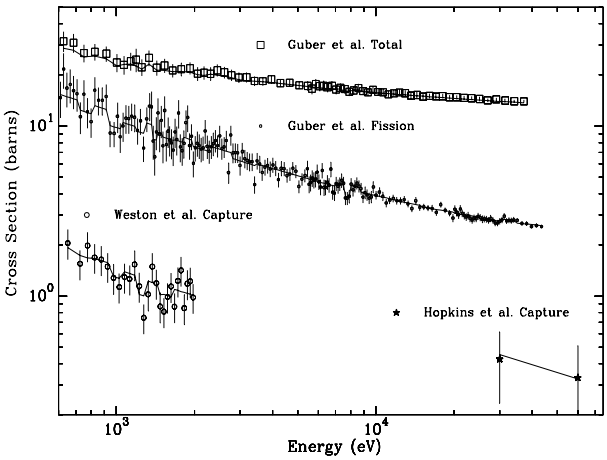

Fig. 1. Comparisons of average cross sections calculated with SAMMY with the experimental data.

In conclusion, an unresolved resonance evaluation of the experimental data in the energy region from 600 eV to 40 keV was performed with SAMMY. The resulting parameters obtained in the evaluation represent the fluctuation in the experimental data well, and it is expected to produce better calculation results for reactor applications. The evaluation has been accepted for inclusion in the future ENDF/B-VII library.

REFERENCES

1. N. M. LARSON, *Updated Users' Guide for SAMMY: Multilevel R-Matrix Fits to Neutron Data Using Bayes' Equations*, ORNL/TM-9179/R6 (July 2003).

2 K. H. GUBER, R. R. SPENCER, L. C. LEAL, P. E. KOEHLER, J. A. HARVEY, R. O. SAYER, H. DERRIEN, T. E. VALENTINE, D. E. PIERCE, V. M. CAULEY, T. A. LEWIS, Nucl. Sci. Eng., 139, 111-117 (2001).

3. H. DERRIEN, J. A. HARVEY, K. H. GUBER, L. C. LEAL, and N. M. LARSON, Average Neutron Total Cross Sections in the Unresolved Energy Range from ORELA High Resolution Transmission Measurements, ORNL/TM-2003/291 (2004).

4. K. H. GUBER, R. R. SPENCER, L. C. LEAL, J. A. HARVEY, N. W. HILL, G. DOS SANTOS, R. O. SAYER, D. C. LARSON, Nucl. Sci. Eng., 135, 141-149 (2000).

5. L. W. WESTON, R. GWIN, G. DE SAUSSURE, R. R. FULLWOOD, R. W. HOCKENBURY, Nucl. Sci. Eng., 34, 1-12 (1968).

6. J. C. HOPKINS, B. C. DIVEN, Nucl. Sci. Eng., 12, 169-177 (1962).